Jerrold E. Marsden
1942-2010

Author of 21 books and over 200 archival and conference papers, Jerrold Eldon Marsden was born in the small papermill company town of Ocean Falls, British Columbia, on August 17, 1942. His love of mathematics was sparked in high school (Burnaby South, BC). He took a BSc at the University of Toronto in 1965, publishing his first research paper that year, followed by a PhD at Princeton in 1968, where he worked with the mathematical physicist Arthur Wightman. While at Princeton Jerry and Ralph Abraham collaborated on the *Foundations of Mechanics* (1967), a seminal work in the new field of geometric mechanics that Jerry later did so much to shape (a second, much expanded edition appeared in 1978).

Jerry then began his teaching career as a lecturer in mathematics at the University of California, Berkeley, where he remained for 27 years, with occasional absences for visiting positions, including 18 months at Cornell and two Humboldt Fellowships in Germany. In 1995 he moved to Caltech, ultimately becoming the Carl F. Braun Professor of Engineering, Control and Dynamical Systems, and Applied and Computational Mathematics, where he also directed the Center for Integrative Multiscale Modeling and Simulation (CIMMS) from 2001.

It is difficult to select from Jerry's many contributions, but his classic 1970 paper with David Ebin on the analysis of fluid flows is a worthy beginning. In 1966 the great Russian mathematician V.I. Arnold (who died earlier this year) reformulated the equations of fluid dynamics in geometric language. Jerry and David Ebin very cleverly employed solution techniques from ordinary differential equation theory to solve these equations. Jerry's colleague Stephen Smale has remarked that the paper "provided an elegant way of presenting old and new fundamental work on the Navier–Stokes and Euler equations . . . and one of the first important uses of infinite dimensional manifolds."

In collaboration with his student Tudor Ratiu, Alan Weinstein, and many others, Jerry went on to develop deep geometrical foundations, under the general rubric of reduction theory, for a broad range of problems in classical and continuum mechanics. (This started in 1974 with a 10-page paper that Jerry and Alan published in *Reports on Mathematical Physics*.) Their group-theoretic viewpoint incorporated symmetries,conservation laws, holonomic and nonholonomic constraints, and control algorithms in a natural way. Over the last 35 years, it has yielded a spectacular array of analytical studies and numerical algorithms for the solution of practical problems, many of them developed by Jerry, his students, and collaborators. In 1993 Jerry noted that "one can say—perhaps with only a slight danger of oversimplification—that reduction theory synthesizes the work of Smale, Arnold (and their predecessors of course) into a bundle, with Smale as the base and Arnold as the fiber."

Jerry also made significant contributions to relativity theory with Arthur Fisher and others, as well as to elasticity theory, co-authoring *Mathematical Foundations of Elasticity* (1983) with his former master's student Tom Hughes. Jerry was an early exponent of bifurcation theory and did much to extend finite-dimensional techniques of dynamical systems theory to the infinite-dimensional phase spaces of partial differential equations. Yet even while developing abstract ideas and methods in geometric mechanics and dynamics, he never lost sight of the details and the painstaking calculations necessary for success in such projects as proving the existence of chaotic solutions in specific differential equations, computing spacecraft orbit trajectories with a group at NASA's Jet Propulsion Laboratory for the 2001 Genesis Discovery mission, and collaborating with his colleague Michael Ortiz to simulate material behavior in the crushing of aluminum cans.

After moving to Caltech, Jerry developed close connections with a number of new groups interested in the applications of geometry, mechanics, and control theory to problems in science and engineering. He was a founding member of the control and dynamical systems department, whose interdisciplinary PhD program provided many of his recent students. During this time he did substantial work to build up the theories of nonhomologically constrained mechanical systems with symmetry and Lagrangian control systems, and, in collaboration with Naomi Leonard, Tony Bloch, and others, he developed the rich and elegant theory of controlled Lagrangians. He also began his work in variational integrators, which exploited the underlying geometric structures to produce numerical integrators capable of preserving important properties, such as energy and momentum.

This work expanded into studies of optimal control problems and led to the development of DMOC (discrete mechanics and optimal control) methods, which are used to solve trajectory-generation problems for mechanical systems. Jerry's emphasis on the need for basic theory in designing computational methods was a key theme in the CIMMS program that he directed, and his ideas also found their way into programs with JPL, where he also had many collaborators. His insight that the structure of stable and unstable manifolds of saddle-type orbits can be used to steer spacecraft through long, fuel-efficient tours of the solar system reconnected deep ideas in geometric dynamics with modern celestial mechanics. Jerry was also a leader in the development of the theory of Lagrangian coherent structures, which he applied to the modeling of ocean circulation and underwater robotics. Throughout, he continued to teach courses that inspired students in a variety of disciplines, including freshman mathematics, which he volunteered to teach several times, most recently in the spring of 2010.

Jerry did much to advance the mathematical sciences in North America and beyond, especially in his role as founding director of Canada's Fields Institute, based initially at the University of Waterloo and since 1995 at his alma mater in Toronto. He served on the SIAM Board of Trustees, as a principal editor of Springer's Applied Mathematics book series, and on the boards of the *Journals of Mathematical Physics* and of *Geometry and Physics*, *Proceedings of the Royal Society*, the *Canadian Journal of Applied Mathematics*, and *SIAM Journal on Applied Dynamical Systems*, among others. He was a member of numerous program and lecture committees, and was co-chair of the Scientific Program Committee for the 2011 International Congress on Industrial and Applied Mathematics that will be held next summer in Vancouver, BC. He took on, and discharged with admirable efficiency, more than his share of editorial and reviewing duties: In mid-August he was still processing papers for the *Journal of Nonlinear Science*, of which he had been editor-in-chief since 2005.

Jerry's work was recognised by major awards, including SIAM's John von Neumann Lecture (2005) and the joint AMS/SIAM Norbert Wiener Prize (1990), and by election to the Royal Societies of London and Canada, and the American Academy of Arts and Sciences. But above these well-deserved honors, it is most fitting at this time to remember Jerry's encouragement and mentorship of young people. Few realise that a large part of research is actually teaching: teaching bright but sometimes erratically educated students the necessary background and methods, teaching colleagues and collaborators about new advances, and teaching oneself all the things that no one else has done. In his multiple textbooks at all levels, in his conference presentations, and in the lecture hall, Jerry was a master teacher, delivering deep ideas with elegance, polish, and humor. His textbook *Vector Calculus*, written with Tony Tromba and subsequently translated into Spanish, Portuguese, German, and Greek, has been in print for 35 years; he was preparing a sixth edition when he died.

His impact is enormous: In more than 42 years, he advised 48 PhD theses and 7 MSc theses, and mentored almost 40 postdoctoral fellows, and it is impossible to definitively count the number of fellow mathematicians, scientists, and engineers with whom he collaborated, or whose careers and lives he touched. He was especially generous to young visitors (for many of whom he raised the funds that made the visits possible) and to students of others, and he responded promptly and attentively to the many who wrote or approached him with questions at conferences and workshops. He managed to do this without compromising the depth of his ideas and thoughts.

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